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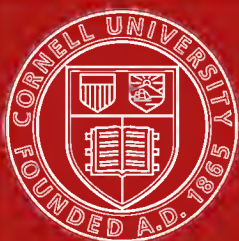
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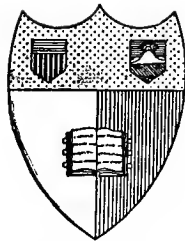
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ORTHOGRAPHIC BEAUTY

OF THE

PARTHENON.

I AM INCLINED TO BELIEVE SOME GENERAL LAWS OF THE CREATOR PRE-VAILED WITH RESPECT TO THE AGREEABLE, OR UNPLEASING AFFECTIONS OF ALL OUR SENSES; AT LEAST THE SUPPOSITION DOES NOT DEROGATE FROM THE WISDOM OR POWER OF GOD, AND SEEMS HIGHLY CONSONANT TO THE SIMPLICITY OF THE MACROCOSM IN GENERAL.—

SIR ISAAC NEWTON.

THE
ORTHOGRAPHIC BEAUTY
OF THE
P A R T H E N O N

REFERRED TO
A LAW OF NATURE.

TO WHICH ARE PREFIXED A FEW OBSERVATIONS ON
THE IMPORTANCE OF ÆSTHETIC SCIENCE
AS AN ELEMENT IN ARCHITECTURAL EDUCATION.

BY
D. R. HAY, F.R.S.E.

WILLIAM BLACKWOOD AND SONS,
EDINBURGH AND LONDON.

M.DCCC.LIII.



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TO
THE REVEREND
PHILIP KELLAND, M.A., F.R.SS. L. & E.
PROFESSOR OF MATHEMATICS, ETC., IN THE UNIVERSITY OF EDINBURGH,
AS A VERY INADEQUATE EXPRESSION OF GRATITUDE
FOR MUCH VALUABLE ASSISTANCE RENDERED ON THE PRESENT
AND ON SEVERAL FORMER OCCASIONS,
THIS TREATISE IS DEDICATED
WITH THE RESPECTFUL ESTEEM AND SINCERE REGARD
OF
THE AUTHOR.

P R E F A C E.

BEING anxious that my theory, as applied simply to the orthography of architecture, should be brought before the highest tribunal which this country affords, in order that its truth might be thoroughly tested before it was offered to the public, I took the liberty of sending the substance of the following pages, accompanied by ample illustrations, as a communication to the Royal Institute of British Architects, and it was read at a meeting of that learned body by one of the members, on the 7th February 1853. The result of this appeal is given at the end of an abstract of my communication printed by the Council for the use of the members, and is in the following words:—

“ Several members present offered observations on the paper which had been communicated, and certain

objections were made to portions of the diagrams exhibited in illustration, and to the system of dividing proportions by particular angles, however convenient in some instances, on which the principle set forth by Mr Hay was based. Testimony was at the same time borne to the value of his labours in pointing out a system round which members might form their own conclusions. It was held to be very difficult to arrive at any complete or general system for the Parthenon—so much so as to induce some investigators to believe that no fixed formula in its strictest sense existed. Still any person who produced a system with apparently fair grounds of support must be considered as conferring a benefit on the study of Grecian architecture, inasmuch as it would lead to the more complete sifting of the evidence, and might thus serve to establish such points as admitted of proof.

“ The paper communicated by Mr Hay embraced so many points connected with geometry, mathematics, and æsthetics, that it was felt to be impossible to grasp the whole of so elaborate a subject upon merely hearing it read—or to arrive at any proper conclusion upon its contents without mature deliberation. Subjects like the present were of great value, by bringing the mind to investigate the laws of nature, and to discover, if possible, whether there was really

any mathematical law coinciding with the harmony always found in nature, which could be applied in the construction of buildings."

Being unavoidably absent from the meeting at which my paper was read, I was prevented from hearing the observations made upon it by the members, or the objections taken to parts of some of the diagrams alluded to in the above report; and, notwithstanding many attempts to become acquainted with their specific nature, I have as yet received no such information as would enable me to enter into details on that part of the subject.

As to the general objection made "to the system of dividing proportions by particular angles," I have only to express a hope that every unprejudiced and careful reader of this short treatise will pronounce that objection groundless.

That it has been "very difficult to arrive at any complete or general system for the Parthenon," the failure of the innumerable attempts that have been made to that effect sufficiently proves. I trust, however, that the following pages, with their illustrations, will shew that the difficulty in question has not proved insurmountable, and that those investigators who were induced "to believe that no fixed formula in the strictest sense existed," simply because they

could not discover it, will be induced, on an acquaintance with this treatise, to change their opinion upon that point.

As to the many points connected with geometry, mathematics, and æsthetics alluded to, I own they are sufficient to render it difficult for any one to grasp the whole subject upon merely hearing it read; but, at the same time, I feel assured that whoever takes the trouble to examine the following pages and their illustrations with ordinary care and attention (however slight his acquaintance with mathematics and geometry may be), will find the subject of easy comprehension, and much more simple in its nature than it at first sight appears.

As I am neither a member of the Institute, nor even an architect, I cannot conclude this preface without gratefully acknowledging the kind condescension of the Council, in not only allowing my paper to be read, but in circulating the considerate and favourable observations which accompanied the abstract of its contents, quoted above.

D. R. HAY.

JORDAN BANK, *April* 1853.

PART I.

IMPORTANCE OF ÆSTHETIC SCIENCE AS AN ELEMENT OF ARCHITECTURAL EDUCATION.

It is well known that architecture owes its excellence to power which it possesses of uniting in its productions qualities of fitness, strength, and beauty. As a useful art demands of its professors, in the first place, a knowledge of various domestic requirements of man, both as a private individual and as a member of civilised society, in order that fits may characterise their designs—from that of the cottage to the palace—from that of the cotton-mill to the cathedral; and in the second place, it requires that they should possess a knowledge of the various branches of mechanical science, in order that they may be enabled to impart to their works the great strength and durability of which the material at their disposal is susceptible.

But, as a fine art, it likewise requires that its professors should be acquainted with the science of æsthetics, in order that the beauty of their works may be, like the qualities of fitness and strength, of a demonstrable and intelligible character. This science of artistic beauty is understood to hold an intermediate position between those sciences that are o

physical, and those that are of a metaphysical character, partaking to some extent of both. It exclusively relates to impressions made by external nature upon the human mind through the organs of the art-senses, as Dr Oken appropriately denominates those of hearing and seeing; and by its means harmonic proportion is as capable of being taught, in respect to abstract forms, as it is in the art of music with respect to abstract sounds. When we reflect that, in all civilised nations, the works of the architect are necessarily placed before the public eye in far greater number and magnitude than those of any other formative artist, and that they thus exercise a powerful influence either to improve or to pervert the perception of the beautiful—either to refine or to degrade the national taste—the importance of this science as an element of architectural design must at once be acknowledged. Not but that men of great artistic genius sometimes appear who are enabled by this rare gift to compose the abstract forms of an architectural structure, agreeably to the successive harmony of its outline, and the combined harmony of the relative proportions of its various parts. But the occurrence of such phenomena does very little towards that general improvement of which the architecture of the present day is susceptible; for such men of genius compose the forms which make up their designs by the eye alone, just as the musical amateur, unacquainted with the laws of harmony, would compose an overture by the ear. It is therefore impossible for them to instruct the numerous less gifted men, who devote themselves to the study of this profession, in those simple laws by which they might at least avoid producing deformity, if they had not the genius to create beauty.

Could genius be analysed, I believe it would generally be found to exhibit a mind in which one or more of the sciences develop themselves in a more than ordinary degree. This

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intuitive possession of science called genius, does not, however, include a knowledge of the principles which constitute science thus developed, and, consequently, does not enable those who possess it to instruct mankind generally in its nature, so as to improve their perception, by enabling them to distinguish, in works of literature and art, the true from the false.

Poetic genius, for instance, exhibits a development of metaphysical, æsthetical, and physical science; and thus the poet is enabled to convey to the minds of other men, in æsthetically constructed language, the creations of his imagination with respect to the workings of the human feelings and passions, and to describe, often very vividly and correctly, various objects in the animal and vegetable creation, as well as the general appearance of external nature in those various aspects by which the mind of man is often so much affected.

Musical genius, on the other hand, exhibits more a development of æsthetical science than of any other; because, in the absence of song, a musical composition addresses the ear by means of the artistic combination of abstract sounds, and by using no definite language, affects the mind by its successive combined harmony alone.

It is with the eye as with the ear—the genius which constitutes the true sculptor and painter, like that which constitutes the true poet, exhibits a development of metaphysical, æsthetical, and physical science; for each in his own way conveys to the minds of other men, in æsthetically constructed works, conceptions which treat of the affections and passions of the human mind, while, at the same time, he confines himself to the truth of nature.

The genius which constitutes the true architect, and by which he is enabled to create beauty, and thereby convey the pleasing feeling of harmony to the mind, exhibits, like that of

musical composer, more an intuitive development of æsthetical science than of any other ; because an architectural work addresses the eye, by means of the artistic combination of abstract forms, and, as such a combination cannot express through that organ any idea of vital action or mental emotion, in definite language, it must depend for the effect it is intended to produce on the mind, on the successive and combined harmony of its various parts. All these fine arts are to some extent imitative. The poet imitates external nature by æsthetic description. The musical composer occasionally imitates natural sounds—from the melodious song of the bird to the discordant noise of the storm ;—but his imitations are not addressed to the mind so definitely as those of the poet, because they are introduced into a composition of abstract sounds, necessarily arranged according to a precise law, and to this law these imitations of natural sounds must also be subjected.

Sculpture and painting are more directly imitative in addressing the mind through the eye than either poetry or music are in addressing it through the ear. But still their imitations, if too palpable, that is, if not æsthetically treated, cease to be works of fine art.

In architecture, imitations of natural objects seem only to be admissible as embellishments to the general structure, and when so used, must be treated as Callimachus treated the acanthus in designing the Corinthian capital, that is, they must be geometrically harmonised.

I believe I have now to some extent made it appear that the nature of a genius adapted to infuse beauty into a musical composition, and a genius adapted to infuse the same quality into an architectural structure, are identical, and that the science which each of those kinds of genius develops is fundamentally that of æsthetics.

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In the art of musical composition, the laws of this science have been long understood and practically applied, the consequence of which is, that the public ear has been trained to distinguish harmony from discord. In this art, therefore, one can become professional without a systematic knowledge of those laws; hence, although devoid of that genius by which he might create beauty, he still has that knowledge by which he may avoid error in the practice of his art. But in relation to the combination of abstract forms in architectural structures there is not as yet any recognised method of practically applying those æsthetic laws, the existence of which all enlightened men now acknowledge. The consequence of this necessarily is, that numerous class of the profession who are devoid of genius, may, and do, indulge themselves with impunity in the production of original designs which exhibit all sorts of puerile and ridiculous fancies; and when they adopt a classical style, or imitate some ancient structure, it is found that “the soul is wanting, though some semblance of the external elements, like an ætæon mask, may be substituted.” This being only apparent, however, of genius, or such as have deeply studied the subject, the public eye is perverted by being constantly subjected to the influence of the great exhibition of the works of architects of all grades, which every modern city affords. On the perception of the eye in respect to proportion, Professor Cockerell has made the following excellent observation—“Custom, conventional notions, and incapacity of discernment, reconcile us to those proportions we are most used to, and we are blind to those which a fresh and accomplished eye is at once shocked at. The sense of vision so studied by the Greeks, is to be educated like the moral sense, and every other by the diligent culture of science;” and farther observes that—“The intelligent artist recognises the claim which this great element of

above all others on his studious attention ;” that “he seizes with extreme delight any rule that will conduct his works to the excellence so apparent and so universally admitted in the Greek proportions—he rejoices in any the slightest elements of their grammar and syntax, by which he can attain to their eloquent language—and he confesses that, without them, all is caprice, hazard, and fashion.” *

It is, therefore, evident that architectural design, generally speaking, must depend for its improvement upon the universal inculcation of a knowledge of such a law of nature as, when applied to abstract form, would meet a response in that inherent quality of the mind which enables every man, more or less, to appreciate the beautiful.

The following contains a brief outline of my system, which will be applied to the Parthenon in the Second Part :—

The elementary forms of architecture are, like the elementary sounds in music, few and extremely simple in their nature. We are accustomed in all cases to refer direction to the horizontal and vertical lines. When these lines meet they make the right angle, which may with safety be assumed as the fundamental angle, from the divisions of which, by the simple numbers 2, 3; 5, 7, or multiples of these primes, the beauty of every architectural design is to arise. When two lines thus making a right angle are joined by an oblique line, the three form the right-angled triangle, which is the primary elementary figure of every other figure employed in architecture. When the two angles made by the oblique line with the vertical and horizontal lines are equal, this triangle may be termed simply the triangle of ($\frac{1}{2}$), because the smaller angles are each one-half the right angle. But when the two angles are unequal, the triangle may be named after the smaller of

* *On the Architectural Works of William of Wykeham.* London, 1846.

OF THE PÁRTHENON.

these. For instance, when the smaller angle, which we shall here suppose to be one-third of the right angle, is made with the vertical line, the triangle may be called the vertical scalene triangle of $(\frac{1}{3})$, and, when made with the horizontal line, horizontal scalene triangle of $(\frac{1}{3})$. As every rectangle is made up of two of these right-angled triangles, the same terminology may also be applied to these figures. Thus the perfect square is the rectangle of $(\frac{1}{2})$, being composed of two similar right-angled triangles of $(\frac{1}{2})$; and when two vertical scalene triangles of $(\frac{1}{3})$ and of similar dimensions are joined by their hypotenuses, they form the vertical rectangle of $(\frac{1}{3})$; as in like manner two horizontal triangles of $(\frac{1}{3})$ united under similar circumstances would form the horizontal rectangle of $(\frac{1}{3})$. As the isosceles triangle is, in like manner, composed of two right-angled scalene triangles joined by one of their sides, the same terminology applies equally to every variety of that figure.

Each of these rectilinear figures has a curvilinear figure that exclusively belongs to it, and to which may be applied a similar terminology. For instance:—1st, The circle belongs to the perfect square, and may be termed simply the curvilinear figure of $(\frac{1}{2})$; because, if two axes be drawn through the centre at right angles to each other, and the extremities be joined, they will form two right-angled triangles of $(\frac{1}{2})$. 2d, The ellipse belongs to the horizontal or vertical rectangle, and may be termed simply the curvilinear figure of $(\frac{1}{3})$, $(\frac{1}{4})$, &c., for a like reason; so that the horizontal or vertical ellipse of $(\frac{1}{3})$, $(\frac{1}{4})$, $(\frac{1}{5})$, or any other proportional part of the right angle, would be quite intelligible and, 3d, The composite ellipse which belongs to every isosceles triangle, and to which the same terminology may be applied.

Thus the elementary figures which belong to all the forms employed in classical architecture are all ruled by a horizontal or vertical right-angled triangle, and are comprised in—

The perfect square or equilateral rectangle,
 The oblong rectangle,
 The isosceles triangle,
 The circle,
 The ellipse, and
 The composite ellipse.*

The law by which these six elementary figures may be harmoniously combined, is a simple and well understood law of nature, and the mode of its application ought to be equally natural and simple. I therefore lay down two positions, the first of which is, that the eye is influenced in its estimation of spaces by a simplicity of proportion similar to that which guides the ear in its appreciation of sounds; for it is reasonable to conclude, that an element which is so necessary to the satisfaction of the one sense, should be also requisite to the complete gratification of the other. The second is, that the eye

* The latter figure, being new and very little understood, and as I have of late greatly improved it, I may here state that the composite ellipse is simply a figure composed of arcs of various ellipses, harmonically flowing into each other whose foci are placed on the sides of an inscribed isosceles triangle, and it thus closely resembles the parabolic and hyperbolic curves. But it has what these curves have not, viz., the essential quality of inscribing harmonically one of the rectilinear elements of architecture, while the parabola and hyperbola are mere curves of motion, which never can harmonically inscribe or resolve themselves into a figure of any kind.

The simplest method of describing it is as follows :—

Plate I.

Construct an isosceles triangle ABC, Plate I. Fig. 1; bisect AB in D; through D draw DE at right angles with AB, and through B draw BE, making with AB the angle of (4). Take AD and DE as the semi-axes of an ellipse, the foci of which will be at G and F. Fix corresponding foci HI and KL in the lines AC and BC. Fix pins in each of the foci F, G, H, I, L, and K, and, in the point E where BE and DE intersect one another, fix a seventh pin. Tie a string flexible but free from elasticity, around the seven pins with a knot that will not slip; withdraw the pin from the point E, and the string will then necessarily lie loosely about the other six points. Introduce a pencil, or any other tracing point, within the circumference of the string, by which, bring it up to its original tension, retaining it so while you move the point around the six foci. The figure thus described will be found to be composed of twelve arcs of ellipses thus distributed: The arcs *ab*, *ef*, and *ik*, are those of three ellipses, whose foci

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guided in its estimate by direction rather than by distance just as the ear is guided by number of vibrations rather than by magnitude; and I reckon it equally reasonable to conclude that the failure of all attempts to discover the operation of harmonic ratio amongst the various parts of the architectural structures of antiquity, has occurred from length, and not direction, being made the standard of comparison—from the attempt to apply simplicity of linear, not of angular, proportion.

The basis, then, of my theory is this, that a figure is pleasing to the eye in the same degree as its fundamental angles bear to each other the same proportions that the vibrations bear to one another in a chord of music. Now as the whole science of musical harmony depends upon the simple division into which a monochord, when in a state of vibratory motion resolves itself by nodes into $(\frac{1}{2})$, $(\frac{1}{3})$, $(\frac{1}{5})$, and $(\frac{1}{7})$, with their sub-multiples, $(\frac{1}{4})$, $(\frac{1}{6})$, &c.; so, in like manner, the whole science of proportion or harmony of form arises from a sim-

are FL , GL , and HK . The arcs bc , de , fg , hi , kl , and ma , are those of six ellipses whose foci are FH , GK , FL , KI , HL , and GI . The arcs cd , gh , lm , are those of three ellipses whose foci are FG , KL , and HI . And upon examination it will be found that the angles of these three kinds of ellipses are to each other in the simple ratio of 3 : 4 : 5, and that the major axis of that whose arc fills the space ef is vertical; that the major axis of that which fills the space ml is horizontal; and that the major axes of the others are in the various degrees of harmonic obliquity of $(\frac{1}{18})$, $(\frac{5}{18})$, $(\frac{7}{18})$, and $(\frac{11}{18})$. I have illustrated the composite ellipse by this example, as it is the most perfectly symmetrical of all others, just as the equilateral triangle which it inscribes is the most perfect of isosceles triangles.

In further illustration, I shall in this place add one other example of this figure. Let the triangle ABC , Plate I. Fig. 2, be that of $(\frac{1}{3})$; make the angle DBE equal to the angle ABC , and describe the composite ellipse by the process already explained. The angles which govern this figure, it will be observed, differ from each other, in the same ratio as the angle of the triangle is $(\frac{1}{3})$ and that which determines the axis of the composite ellipse to be inscribed around it $(\frac{1}{4})$, so that the first bears to the second the harmonic ratio of 4 : 3. By this means the arcs ab , ef , and ik are rendered almost imperceptible, and the inscribing curve almost touches the angles B and C , which gives a more decided character to this figure than is to be found in any other. In all composite ellipses in which the governing angles differ, it is required to amplify their terminology by naming both angles, and I therefore term the vertical composite ellipse of $(\frac{1}{3})$ and $(\frac{1}{4})$. To this figure I shall again have to refer in the sequel.

division of the quadrant of a circle. The highest standard of symmetry, so estimated, is thus deduced from the law that the angles of direction must all bear to some fixed angle relations expressed arithmetically by the smallest natural numbers. I am strengthened, by high authority, in the conviction that no other law can be devised half so simple as this; that it accords with the other laws of nature, being but another form of that great *law of least effort* which pervades and regulates the system of the universe; that the labour it imposes on the eye is simply to measure round a point, and that the measures it demands are the easiest and readiest which could possibly be required, viz., to estimate the halves, the thirds, and the other simple proportions of the assigned unit. Also, that no other law could give such repose to the eye, or present its results to the mind, in a form so plain and unmistakable, for it is exhibited under a form, which we know the mind to be capable of judging from, being the identical form under which the ear presents to it an harmonious combination of sounds; and it certainly is in perfect consonance with the wisdom of the Creator, to find sensations so widely different as these brought back to the same ultimate type. Agreeably to this law of harmonic ratio, every figure in architecture, whether rectilinear or curvilinear, has an angle which regulates its individual proportions, and at the same time determines its proportional relation to such figures as enter into combination with it, whether that figure represents a projecting or retiring surface. Consequently, the system I adopt is easily applied in every formative art, and its leading elements are included in the following scale of ratios, corresponding to what would be termed in the art of music a diatonic scale of seven octaves, including the flat seventh. To these ratios, therefore, the scientific terms employed in musical composition are applied:—

OF THE PARTHENON.

SCALE OF HARMONIC RATIOS.

Tonics.	Super-tonics.	Mediants.	Sub-dominants.	Dominants.	Sub-mediants.	Subtonic.	Semi
I. 1 : 1	8 : 9	4 : 5	3 : 4	2 : 3	3 : 5	4 : 7	8 :
II. 1 : 2	4 : 9	2 : 5	3 : 8	1 : 3	3 : 10	2 : 7	4 :
III. 1 : 4	2 : 9	1 : 5	3 : 16	1 : 6	3 : 20	1 : 7	2 :
IV. 1 : 8	1 : 9	1 : 10	3 : 32	1 : 12	3 : 40	1 : 14	1 :
V. 1 : 16	1 : 18	1 : 20	3 : 64	1 : 24	3 : 80	1 : 28	1 :
VI. 1 : 32	1 : 36	1 : 40	3 : 128	1 : 48	3 : 160	1 : 56	1 :
VII. 1 : 64	1 : 72	1 : 80	3 : 256	1 : 96	3 : 320	1 : 112	1 :

These harmonic ratios may be applied in the formative a simply by dividing the circumference of the quadrant of a ci into the following parts, and using this divided quadrant a protractor :—

I.	(1)	($\frac{8}{9}$)	($\frac{4}{5}$)	($\frac{3}{4}$)	($\frac{2}{3}$)	($\frac{3}{5}$)	($\frac{4}{7}$)	($\frac{8}{15}$)
II.	($\frac{1}{2}$)	($\frac{4}{9}$)	($\frac{2}{5}$)	($\frac{3}{8}$)	($\frac{1}{3}$)	($\frac{3}{10}$)	($\frac{2}{7}$)	($\frac{4}{15}$)
III.	($\frac{1}{4}$)	($\frac{2}{9}$)	($\frac{1}{5}$)	($\frac{3}{16}$)	($\frac{1}{6}$)	($\frac{3}{20}$)	($\frac{1}{7}$)	($\frac{2}{15}$)
IV.	($\frac{1}{8}$)	($\frac{1}{9}$)	($\frac{1}{10}$)	($\frac{3}{32}$)	($\frac{1}{12}$)	($\frac{3}{40}$)	($\frac{1}{14}$)	($\frac{1}{15}$)
V.	($\frac{1}{16}$)	($\frac{1}{18}$)	($\frac{1}{20}$)	($\frac{3}{64}$)	($\frac{1}{24}$)	($\frac{3}{80}$)	($\frac{1}{28}$)	($\frac{1}{30}$)
VI.	($\frac{1}{32}$)	($\frac{1}{36}$)	($\frac{1}{40}$)	($\frac{3}{128}$)	($\frac{1}{48}$)	($\frac{3}{160}$)	($\frac{1}{56}$)	($\frac{1}{60}$)
VII.	($\frac{1}{64}$)	($\frac{1}{72}$)	($\frac{1}{80}$)	($\frac{3}{256}$)	($\frac{1}{96}$)	($\frac{3}{320}$)	($\frac{1}{112}$)	($\frac{1}{120}$)

Besides these, there are other ratios by which the series n be interpolated, but, being less simple, they are of a less h monic character. But the above will be found quite suffici for general practice, and those who wish to go more dee into the subject will find sufficient details in the Appendix one of my former works.*

Nor let it be supposed, either that so numerous an array ratios will involve us in anything complicated, or that, w so many before us, the whole is simply matter of interpolati

* "The Geometric Beauty of the Human Figure defined, to which is prefix System of *Æsthetic Proportion applicable to Architecture*," &c.

whereby, should the first and third fail, we have always a second at hand lying between these, and sufficiently near to both to effect every purpose. In reply to both these charges, I could fearlessly appeal to my treatise *on the Human Figure*,* where it will be seen that lines drawn from the two extremities of the figure formed, with the vertical line, the $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, and $\frac{1}{8}$ th of a right angle, and that these, and these only, determine every point of importance in the outline. And with equal confidence could I appeal to Plate II. of the present treatise, and the description pp. 26, 27, where the angles BAC, BAD, BAE, CGD, or $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, and $\frac{1}{7}$ th of a right angle, determine so vast an amount of the outline, and regulate so harmoniously the proportions of the Parthenon. The theory in both cases is precisely the same. The most beautiful form in nature, and the most beautiful form created by art, *must* be governed by some one law. To one law I have attempted to reduce them. The human figure exhibits, more than any other object in nature, an equally balanced combination of those three qualities which ought to be found in every architectural structure—fitness, strength, and beauty. If what I have advanced be correct, the mystery which has hitherto hung over the last of these qualities has been removed, for it has been proved that the natural principles of the æsthetic development of the human figure were but another expression of that great and universal law of nature which, while it governs the motions and relative distances of those bodies which constitute the universe, also regulates the harmony by which, through the art-senses, the mind is charmed, gratified, and improved. I also shewed that the mode in which this great law operated in regulating the proportions of the human figure was characterised by perfect uniformity

* "*The Natural Principles of Beauty as developed in the Human Figure.*"

OF THE PARTHENON.

and extreme simplicity, inasmuch as, 1st, That on a given line the human figure is developed as to its principal points entirely by lines drawn either from the extremities of this line, or from some obvious and determined localities; 2d, That the angles which those lines make with the given line are simple submultiples of some given fundamental angle; 3d, That the contour may be resolved into a series of ellipses of the same simple angles; and, 4th, That in the front geometrical view of the figure, these ellipses, like the lines, are inclined to the given line, by angles which are simple submultiples of the given fundamental angle.

Thus I found in the noblest work of creation, which is universally acknowledged to exhibit the highest example of perfect mechanical science, sustained in vital energy by the most wonderful chemical processes, a development of perfect geometric harmony, not only in the relative proportions of parts, but likewise in the curvature of its outline. In order, however, to verify the truth of this discovery, I commenced under the direction, and with the valuable assistance, of Professors Kelland and Goodsir, of the Edinburgh University, a careful investigation into the exact proportions of those beautiful remains of ancient Greek sculpture, the Venus of Medici and Venus of Melos, and had the satisfaction to find that the statues both agreed perfectly with the law in question. Having thus successfully appealed for its truth to the noblest work of creation, and to the finest specimens of art in which that work has been imitated, I now turn to what mankind has, since the revival of the arts, unanimously pronounced to be the noblest combination of abstract forms which human genius, aided by science, has been able to achieve, and which still remains, without exception, the most magnificent ruin in the world, namely, the Parthenon of Athens.

PART II.

THE ORTHOGRAPHIC BEAUTY OF THE PARTHENON.

THE Parthenon, or temple of the virgin goddess Athene, or Minerva, the protectress of Athens, is situated on the Acropolis of that city. This temple was erected in the time of Pericles (about B.C. 448). Ictinus and Callicrates were the architects.

“The Parthenon,” says the editor of the last edition of Stuart’s *Athens*, “is one of the most highly finished edifices of Greece, and perhaps the largest octa-style temple of antiquity ever completed. It still rears its majestic columns triumphantly over twenty-two centuries of duration. We may here figure to ourselves the muse of ideal perfection in art yet in scorn looking down on us from this her favoured seat. Other monuments of antiquity, by the magnitude of their dimensions, and the colossal character of their marbles, may exceed the Athenian Temple, which, though clad with mutilations, the sad records of every species of degradation, supernatural violence, and spoliation, yet the majestic relics still rivet and even oppress the mind, by the sole influence of proportion and harmony of execution. Unlike more extensive monuments which the graver can elevate in the imagination beyond the

power of reality, these surpassing ruins no pen has faithfully described, or pencil adequately depicted. Of all the monuments of ancient and modern magnificence which have been within our view, the grandeur of this alone surpassed anticipation, leaving an impression on the mind, similar to, but more profound, than the charms of an harmonious fugue, or of a rapturous effusion of poesy." Such is the great work, by an analysis of the orthography of which I am about to test the truth of my theory of the natural laws of the harmony of form.

The harmonic angles by which I was enabled to determine the true proportions of the human figure, as represented in ancient Greek Art—and approached to, because deviated from on both sides, in ordinary nature—I found to be twelve in number. The right angle, being the fundamental tonic (1), was thus divided into—

Tonic angles.	Dominant angles.	Mediant angles.	Subtonic angles.	Supertonic angle.
(1)	($\frac{1}{3}$)	($\frac{1}{5}$)	($\frac{1}{7}$)	($\frac{1}{9}$)
($\frac{1}{2}$)	($\frac{1}{6}$)	($\frac{1}{10}$)	($\frac{1}{14}$)	
($\frac{1}{4}$)	($\frac{1}{12}$)			
($\frac{1}{8}$)				

Now it appears that the same number of angles of an equally harmonic character determines the proportions of the elevation of the principal front, or eastern portico of the Parthenon. The right angle, being the fundamental tonic (1), is divided into—

Tonic angles.	Dominant angles.	Mediant angles.	Subtonic angle.	Supertonic angles.
(1)	($\frac{1}{3}$)	($\frac{1}{5}$)	($\frac{1}{7}$)	($\frac{1}{9}$)
($\frac{1}{2}$)	($\frac{1}{6}$)	($\frac{1}{10}$)		($\frac{1}{8}$)
($\frac{1}{4}$)				
($\frac{1}{8}$)				
($\frac{1}{16}$)				

These angles may be used in the formation of a diagram of the elevation in question, agreeably to the following simple formula:—

Plate II. Let the line AB, Plate II., represent the length of the base or upper step. From the point A draw three lines making the angles CAB ($\frac{1}{3}$), DAB ($\frac{1}{4}$), and EAB ($\frac{1}{5}$). Through B draw BC, and through A draw AH, making the angles ABC and HAB (1), *i.e.*, the right angle. Bisect AB in F, and draw FG parallel to CB. Through C draw CGH parallel to AB; through G draw GD, making the angle CGD ($\frac{1}{7}$); through the point D, where the lines AD and GD intersect one another, draw DK parallel to AB; and through the point E, where the lines AE and BC intersect one another, draw EL parallel to DK and EZ, making the angle ZEL ($\frac{1}{16}$).

Through the point *m*, where the lines AE and FG intersect one another, draw β *mp*, making the angle F *mp* ($\frac{1}{6}$), draw *pq* parallel to FG. Make the angles *qsr* ($\frac{1}{10}$), *rut* ($\frac{1}{8}$), *txv* ($\frac{1}{10}$), *vjy* ($\frac{1}{6}$), *ylz* ($\frac{1}{10}$), *zkw* ($\frac{1}{8}$), and *wlp* ($\frac{1}{9}$). Bisect the lines *qr*, *tv*, *yz*, and *wp* in M, and draw the lines MN perpendicular to AB. Draw similar lines on the other side of FG. These lines represent the axes of the columns. The process by which the columns themselves may be proportioned, is as follows:—

Let aNb be the given diameter of the column at its base. Through b draw bc parallel to MN, and through a draw ac, making the angle acb ($\frac{1}{8}$), through c draw cf parallel to EL, and through the point e where ac and MN intersect one another draw ef, making the angle feM ($\frac{1}{10}$), and produce fe until it meets AB in g, and draw go, ad, and fh parallel to MN. Through i draw ifk, making the angle ikM ($\frac{1}{3}$). Draw a similar line lok on the other side of MM. Through i draw

im, making the angle miM ($\frac{1}{10}$). Draw in and lm perpendicular to LE; through m draw XmT parallel to LE; and through o, where AE and the line MN drawn between w and p intersect one another, draw UoV parallel to LE. Through X draw XY, making the angle YXT ($\frac{1}{8}$), and through R where XY intersects FG, draw JW parallel to XT, join YZ, and through the point I, where EZ intersects FG, draw gf parallel to JW. Through d, where AD and ZYd intersect one another, draw da parallel to BC; through b, where da intersects DK, draw bO parallel to GD; through Y draw Ybc, making the angle Ybd ($\frac{1}{2}$). Bisect Yb in e; through e draw eP parallel to DG. Bisect RS in n; through n draw vnu, making the angle Rnu ($\frac{1}{3}$), and through u draw ut parallel to FG; also through u draw ux, making the angle tux ($\frac{1}{2}$).

The diagram thus constructed agrees so closely with the relative measurements of the lengths and breadths of the various parts of the portico as to be sufficient to convince any unprejudiced mind that the harmony of its proportions arises from the angles thus employed. It is true that the inclination of the oblique line of the pediment as constructed is fully half a degree greater than ($\frac{1}{7}$),—that is, it is nearly $13^{\circ} 30'$, which is ($\frac{3}{20}$), instead of being nearly $12^{\circ} 51' 26''$, which is ($\frac{1}{7}$). But this is very easily accounted for by the invisible curve of the base and entablature causing an angle of a less harmonic nature to be adopted, instead of that given in the normal proportions; for “it is easy to see that the main proportions would naturally be established in rectilinear geometrical drawing, and that the modifications due to the curvature, &c., would be an after-process.”*

The whole elevation is thus divided into three distinct portions:—1st, A vertical portion, being a series of vertical curvi-

* Penrose, Chap. II. p. 13.

linear forms arranged between AB and LE; 2*d*, A horizontal portion, being an arrangement of rectilinear figures lying between LE and KD; and, 3*d*, An oblique portion, forming an isosceles triangle between KD and the top.

It has already been explained how the horizontal, vertical, and oblique lines unite in the formation of the most elementary figure in architectural composition—the right-angled scalene triangle,—and it will be seen that the lines I. have drawn in constructing the diagram have necessarily formed themselves into a series of these triangles. I shall therefore now shew the harmonic ratios which the angles of these triangles bear to the horizontal and to the vertical lines.

	Elementary Angles.	Ratios.	Ratios.	Fundamental Angle.
I. EAB	$(\frac{1}{5})$	$\left\{ \begin{array}{l} 1 : 5 \text{ with the} \\ 1 : 4 \text{ horizon-} \\ 1 : 3 \text{ tal line} \end{array} \right\}$	$\left\{ \begin{array}{l} 4 : 5 \text{ with the} \\ 3 : 4 \text{ vertical} \\ 2 : 3 \text{ line} \end{array} \right\}$	(1)
II. DAB	$(\frac{1}{4})$			(1)
III. CAB	$(\frac{1}{3})$			(1)

These are the harmonic ratios which govern the three first grand divisions, and the following are those which govern the details by which the divisions are filled up :—

I.

	Elementary Angles.	Ratios.	Ratios.	Fundamental Angle.
Fmp	$(\frac{1}{6})$	$\left\{ \begin{array}{l} 1 : 6 \\ 1 : 10 \text{ with the} \\ 1 : 8 \text{ vertical} \\ 1 : 9 \text{ line} \\ 1 : 3. \end{array} \right\}$	$\left\{ \begin{array}{l} 5 : 6 \\ 9 : 10 \text{ with the} \\ 7 : 8 \text{ horizon-} \\ 8 : 9 \text{ tal line} \\ 2 : 3 \end{array} \right\}$	(1)
qsr	$(\frac{1}{10})$			(1)
zkw	$(\frac{1}{8})$			(1)
wlp	$(\frac{1}{9})$			(1)
ikM	$(\frac{1}{3})$			(1)

II.

ZEL	$(\frac{1}{16})$	$\left\{ 1 : 16 \text{ with the } \right\}$	$\left\{ 15 : 16 \text{ with the } \right\}$	(1)
YXT	$(\frac{1}{18})$	$\left\{ 1 : 18 \text{ horizon- } \right\}$	$\left\{ 17 : 18 \text{ vertical } \right\}$	(1)
Mil	$(\frac{1}{10})$	$\left\{ 1 : 10 \text{ tal line } \right\}$	$\left\{ 9 : 10 \text{ line } \right\}$	(1)
vut	$(\frac{1}{3})$	$\left\{ 1 : 3 \text{ with the } \right\}$	$\left\{ 2 : 3 \text{ with the } \right\}$	(1)
tux	$(\frac{1}{2})$	$\left\{ 1 : 2 \text{ vert. line } \right\}$	$\left\{ 1 : 2 \text{ hor. line } \right\}$	(1)

III.

CGD	$(\frac{1}{7})$	$\left\{ 1 : 7 \text{ with the } \right\}$	$\left\{ 6 : 7 \text{ with the } \right\}$	(1)
Ybd	$(\frac{1}{2})$	$\left\{ 1 : 2 \text{ hor. line } \right\}$	$\left\{ 1 : 2 \text{ vert. line } \right\}$	(1)

When we compare the ratios thus evolved from the analysis of the orthography of the Parthenon with those evolved from a similar analysis of the proportions of the female figure, as represented in ancient Greek art, we can understand the meaning of Vitruvius when he says, "The several parts which constitute a temple ought to be subject to the laws of symmetry; the principles of which ought to be familiar to all who profess the science of architecture. For no building can possess the attributes of composition in which symmetry and proportion are disregarded, nor unless there exists that perfect conformation of parts which may be observed in a well-formed human being." And in another part, the same ancient author says, "The artists of antiquity must be allowed to have followed the dictates of a judgment the most rational when, transferring to the works of art principles derived from nature, every part was so regulated as to bear a just proportion to the whole. Now, although these principles were universally acted upon, yet they were more particularly attended to in the construction of temples and sacred edifices; the beauties or defects of which were destined to remain as a perpetual testimony of their skill or of their inability."

The following is the result of this comparison :—

Human Figure.		Parthenon.	
1 : 2.		1 : 2.	
1 : 3.	2 : 3	1 : 3.	2 : 3
1 : 4.	3 : 4	1 : 4.	3 : 4
1 : 5.	4 : 5	1 : 5.	4 : 5
1 : 6.	5 : 6	1 : 6.	5 : 6
1 : 7.	6 : 7	1 : 7.	6 : 7
1 : 8.	7 : 8	1 : 8.	7 : 8
1 : 9.	8 : 9	1 : 9.	8 : 9
1 : 10.	9 : 10	1 : 10.	9 : 10
1 : 12.	11 : 12	1 : 16.	15 : 16
1 : 14.	13 : 14	1 : 18.	17 : 18

In proceeding to analyse the visible curves of the Parthenon, I find that they are in perfect agreement with the elementary rectilinear figures which have arisen from the combination of the harmonic angles illustrated in Plate II., for they are simply the following :—

Tonics.	Dominants.	Subtonics.
$(\frac{1}{2})$	$(\frac{1}{3})$	$(\frac{1}{14})$
$(\frac{1}{4})$	$(\frac{1}{6})$	
$(\frac{1}{64})$		

In addition to the angles in the first scale, the following are now required to be added in order to complete the harmony of this portion of the design :—

Tonic.	Dominant.	Mediant.	Submediant.	Subtonic.	Semi-subtonic.	Supertonic.
$(\frac{1}{64})$	$(\frac{1}{48})$	$(\frac{2}{5})$	$(\frac{3}{10})$	$(\frac{1}{14})$	$(\frac{8}{15})$	$(\frac{2}{9})$
						$(\frac{4}{9})$

I shall commence with the curve called the entasis of the column, upon the nature of which so much has already been written, and so many conflicting opinions advanced.

It appears clear to me that this curve is simply an arc of a composite ellipse of $(\frac{1}{48})$ and $(\frac{1}{64})$, which is the fifth of a series commencing with that of $(\frac{1}{3})$ and $(\frac{1}{4})$, each having the harmonic ratio of 3 : 4 between the angle of the curve and the angle of the inclination of its major axis to the vertical line. The particular arc of this figure is not selected empirically, but is determined by certain definite points. In order to exemplify this on a sufficiently large scale, I shall take the second of the series, a composite ellipse of $(\frac{1}{6})$ and $(\frac{1}{8})$.

Therefore let ABC, Plate III., be a vertical isosceles triangle of $(\frac{1}{6})$, bisect AB in D, and through D draw Df perpendicular to AB, and through B draw Bf making the angle DBf $(\frac{1}{8})$. Taking BD and Df as semi-axes, describe the composite ellipse as already explained whose foci are G, F, K, L, H, and I.

Through the foci G and L draw Ga parallel to BC and Lb parallel to AB. Join ab, and through f draw fo parallel to ab. The relative proportions of the lower and upper diameters of the shaft of the column, and the nature of the curve called its entasis, will now be found between ab and fo.

The shafts of the columns of this portico are therefore simply frustra of an elliptic sided, or prolate spheroidal, cone, whose section is a composite ellipse of $(\frac{1}{48})$ and $(\frac{1}{64})$, and whose curve is to its inclination in the harmonic ratio of 3 : 4.

This Plate exhibits the composite ellipse of $(\frac{1}{48})$ and $(\frac{1}{64})$, Plate as connected with the rectilinear diagram of the column given in Plate II.

This Plate exhibits a section of the shaft of the column, Plate drawn agreeably to the same formula, but on a larger scale.

This Plate represents a section of the face of the capital $\frac{1}{3}$ Plate the full size. The curve of the neck is an arc of an ellipse of $(\frac{1}{6})$, whose major axis AB is in the vertical line. The curve of

the echinus is composed of 3 arcs of an ellipse of ($\frac{1}{14}$), whose major axis at HF is inclined ($\frac{1}{2}$), at GD ($\frac{8}{15}$), and at XT ($\frac{1}{2}$) to the horizontal line. The cavettos of the annulets are likewise arcs of the same ellipse, whose major axes, *ab*, *cd*, *ef*, and *gh*, are inclined ($\frac{1}{2}$), and their fillets arranged upon the same ellipse whose major axis IK is inclined ($\frac{1}{3}$) to the vertical line. The lines drawn perpendicular to *if* represent Mr Penrose's offsets. The lines LE and UV are portions of the same lines on Plate II.

Plate VII. Fig. 1 of this Plate represents a full-sized section of the moulding under the cymatium of the pediment, consisting of the parts termed respectively a cavetto and cyma reversa. The curves of this moulding are arcs of ellipses of ($\frac{1}{3}$), the major axis *ab* of that which forms the cavetto is in the horizontal line, and the major axes *cd* and *ef* of those which form the cyma reversa are inclined ($\frac{1}{4}$) to the horizontal line.

Fig. 2 is a full-sized section of the bed moulding of the cornice of the pediment, the curves of which are arcs of an ellipse of ($\frac{1}{3}$), whose major axes, *gh*, *ik*, and *lm* are inclined ($\frac{2}{3}$) to the vertical line.

Fig. 3 represents the cavetto of the soffit of the corona $\frac{1}{6}$ the full size. Its curve is composed of arcs of two ellipses; one of ($\frac{1}{6}$), whose major axis AB is in the horizontal line, and another of ($\frac{1}{14}$), whose major axis CD is also in the horizontal line. The lines drawn perpendicular to *no* are Mr Penrose's offsets.

Plate VIII. Fig. 1 of Plate VIII. represents a section of the cymatium which surmounts the corona $\frac{1}{3}$ the full size. Its curve is simply an arc of an ellipse of ($\frac{1}{3}$), whose semimajor axis AB is in the vertical line, and whose focus C determines the length of the arc.

Fig. 2 represents a full-sized section of the corona, with the moulding over it of the capital of the autæ of the posticum.

The curves of the moulding are arcs of an ellipse of ($\frac{1}{3}$), whose major axis at cd is first inclined ($\frac{4}{9}$), and then at ef ($\frac{2}{3}$) to the horizontal line.

Fig. 3 represents a full-sized section of the lower moulding of the same capital. It is composed of the parts termed an ovola, a fillet, and a bead; the curve of the first is the arc of an ellipse of ($\frac{1}{3}$), whose major axis mu is inclined ($\frac{1}{6}$) to the vertical line. The fillet under this is inclined ($\frac{1}{10}$) to the vertical line; and the curve of the bead is a semicircle, whose axis is also inclined ($\frac{1}{10}$) to the vertical line.

Plate IX. represents a full-sized section of the moulding Pl_k which lies between the two just described, and completes the capital. It is composed of arcs of an ellipse of ($\frac{1}{3}$), whose major axes gh , ih , lm , is inclined, 1st, ($\frac{2}{5}$) to the horizontal line; 2d, ($\frac{3}{10}$) to the vertical line; and, 3d, ($\frac{2}{5}$) to the vertical line.

This Plate represents a full-sized section of the upper Pl_k moulding of the band under the beams of the ceiling of the peristyle. Its curves are arcs of ellipses of ($\frac{1}{3}$), the major axis of the first op is in the vertical line, and its minor axis qr is equal to the projection of the whole moulding. The major axis of the other ellipse as placed at st and uv is inclined ($\frac{1}{6}$) to the vertical line.

This Plate, Fig. 1, represents a full-sized section of the Pl_k lower moulding of the same band. Its curves are arcs of an ellipse of ($\frac{1}{4}$), whose major axis at xy and wz is inclined ($\frac{1}{2}$).

Fig. 2 represents a full-sized section of the moulding at the bottom of the small step or podium, which extended between the columns of the pronaos and posticum. It has a semicircular bead, whose axis ab is inclined ($\frac{1}{6}$) to the vertical line, and the curves of the lower part are arcs of an ellipse of ($\frac{1}{3}$), and whose major axes at cd and ef are in the horizontal line, and whose foci and centres are in the same vertical line.

Thus have the orthographic proportions and curvilinear details of the principal front of this celebrated edifice been for the first time reduced to a natural principle of beauty.

I shall now look into the methods adopted to discover this law respectively, by the earliest and latest investigators. The work of Vitruvius is the only one on the subject of architecture which has come down to us from antiquity. This author is supposed to have flourished about the times of Julius Cæsar and Augustus. Although I have already quoted his words as bearing testimony to the fact, that a natural law of proportion was systematically applied in architecture by the ancient Greeks, yet it is quite evident that the proper method of its application was unknown to him, for he tries to account for the analogy between the proportions of the human figure and those of a temple in a manner equally fallacious and unsatisfactory. It, therefore, appears that a practical knowledge of this law did not reach down to the period of Vitruvius, which was about four hundred years posterior to the best period of Greek art. The recovery of this important knowledge has been the aim and occupation of critical inquiry among us from the revival to the present day, a period of nearly four hundred years; but nothing has been elicited that can be called a natural and systematic law of harmonic proportion, a law which will, with certainty, produce the fundamental element of the beautiful in architecture, and awaken what Professor Cockerell terms "that sense of rhythmical proportion, and that harmony which affects the mind like a mathematical truth, and, like a concord of musical sounds on the ear, is perceived and confessed as obvious and unalterable."

The latest investigator is Mr Penrose, an architect of London, who, while at Athens in 1846, observed some peculiarities in the curvature of the Parthenon, of which, he says, no adequate

notice had been taken in the works of any former investigator. He, therefore, obtained, through the Society of Dilettanti, the necessary facilities for a careful examination of this great work of ancient art, the results of which have been since published,* and evince on the part of the author the most careful and minute research; and I believe no one can examine the contents of his splendid book, without being convinced of the accuracy of the various measurements, and the care that must have been bestowed on every detail. Notwithstanding this, the conclusions he has arrived at with respect to the æsthetic developments of the Parthenon appear to me to be far from satisfactory. This, evidently, arises in the first place from the method (which seems to have originated with Vitruvius) of making length and not direction the standard of comparison—from the attempt to find linear instead of angular harmony. Mr Penrose, like all who have studied the subject with care, seems firmly to believe that a law of harmonic proportion governed the orthography of this structure; and in regard to that of the principal front, he has anxiously searched for its development in the ratios which exist among the lengths and breadths of the various parts of which it is composed, and all the proofs of the existence of harmony which he has been able to produce by these means consist of the following facts:—

1st, That the entire height to the top of the cymatium of the pediment is to its breadth in the ratio of 7 : 12.

2d, That the height of the column is to the entire height in the same ratio.

3d, That, if the height of the pediment had been 12·556 ft. instead of 12·643 ft., it would have been to the length of the horizontal cornice in the ratio of 6 : 25.

* *An Investigation of the Principles of Athenian Architecture, &c.*, by Francis Cranmer Penrose, Architect, M.A., &c. London: Longman & Co. and John Murray. 1851.

4th, That, if the length of the architrave had been 1.126 ft. less than the upper step, instead of 1.110 ft., which it measures, the length of the architrave to that of the upper step would have been in the ratio of 89 : 90.

5th, That the diminution of the columns is to their height in the ratio of 1 : 50.

This is a most unsatisfactory result; for the ratios thus found are only four in number, and are not exactly harmonic in their nature; whereas, there are eighteen ratios evolved by the angular system, all of which are truly harmonic in their nature, and are to be found in the scale of the leading elements of harmony, p. 21. These I shall place in juxtaposition with the above four:—

Evolved by the Angular System, and arranged in the order of their simplicity.			Evolved by Lineal Measurement.
1 : 2	3 : 4	5 : 6	7 : 12
1 : 3	1 : 7	6 : 7	6 : 25
1 : 4	1 : 8	1 : 16	89 : 90
2 : 3	4 : 5	8 : 9	1 : 50
1 : 5	1 : 9	1 : 18	
1 : 6	1 : 10	9 : 10	

The comparison of these two results shews that the universally acknowledged harmony which pervades the orthography of the Parthenon is found in the angles, and not in the lengths and breadths of its parts, where they have been hitherto searched for; and the conclusion to which this fact necessarily leads is, that the beauty of proportion could only have been imparted to that “most harmonious structure” by the system I have pointed out.

Doubtless, in the course of erecting any great structure, upon whatever system of proportion the orthography may have

been arranged, many accidental circumstances must occur to occasion deviations from exact symmetry, but which, if slight, do not at all injure the general effect; and such appears to have been the case in the building of the Parthenon. For instance, if we take the arrangement of the columns and of the metopes of the principal front, according to Mr Penrose's measurements, we find the following deviations:—

I.	{	The lineal distance between the axes of the	
		first and second columns on the north side	Feet.
		of the centre, being	14·084
		and that between the axes of the first and	
II.	{	second columns on the south side of the	
		centre, being	14·106
		there is a deviation from perfect symmetry	
		of	·022
II.	{	The lineal distance, between the axes of the	
		second and third columns on the north side	
		of the centre, being	14·115
		and that between the axes of the second	
III.	{	and third columns on the south side of the	
		centre, being	14·078
		there is a deviation from perfect symmetry	
		of	·037
III.	{	The lineal distance between the axes of the	
		third and fourth columns on the north side	
		of the centre, being	12·041
		and that between the axes of the third and	
III.	{	fourth columns on the south side of the	
		centre, being	12·147
		there is a deviation from perfect symmetry	
		of	·106

In like manner the corresponding metopes on each side of the centre differ, as follows :—

		Feet.
I.	{ The breadths of the two first are respectively	4·320
	{ and	4·375
	{ shewing a deviation from symmetry of .	·055
II.	{ Those of the two second are respectively .	4·295
	{ and	4·169
	{ shewing a deviation from symmetry of .	·126
III.	{ Those of the two third are respectively .	4·281
	{ and	4·186
	{ shewing a deviation from symmetry of .	·095
IV.	{ Those of the two fourth are respectively .	4·050
	{ and	4·195
	{ shewing a deviation from symmetry of .	·145
V.	{ Those of the two fifth are respectively .	4·064
	{ and	4·192
	{ shewing a deviation from symmetry of .	·128
VI.	{ Those of the two sixth are respectively .	4·066
	{ and	4·120
	{ shewing a deviation from symmetry of .	·054
VII.	{ Those of the two seventh are respectively .	4·160
	{ and	4·121
	{ shewing a deviation from symmetry of .	·039

It could not, therefore, have been by a fastidious attention to the minutiae of lineal measurements that the beauty of harmonic proportion was imparted to the orthography of the Parthenon, as Mr Penrose's investigations would lead us to suppose, but to the application of that universal law of nature which governs all visible beauty. And I may add, that as nature seldom, if ever, produces a human being so perfect in

symmetrical beauty, that a careful and minute scrutiny will not detect in it some deviation from a perfect development of this law, but that this fact neither causes us to doubt the existence of the law, nor is sufficient to destroy our satisfaction in the work ; so we are not bound down to absolute perfection in an artistic combination of abstract forms, however strongly we may feel convinced that the structure owes its harmonic beauty and grandeur to the application of a definite law in its original design.

With reference to this point, Professor Donaldson, amongst his excellent *Architectural Maxims and Theorems*,* says :—
 “ If a difference of size in parts or details exist in a building, and be not discoverable unless one takes a compass, a rule, a square, or a level, they are no longer defects. Buildings are not made for measurement, but delight. When these discrepancies escape the eye, and minute examination can alone detect the irregularity, the beauty of the whole does not cease to affect us. In the Pantheon at Rome, the angular columns are anti-Vitruvian, being smaller, instead of larger, than the others. At the top of the pediment there is a double modillion ; and on one side of the sloping cornice, twenty-four modillions, on the other, twenty-two. ‘ Bravo,’ says Milizia, ‘ to him who has counted them ; but *più bravo* to him who turns up his nose at such microscopic criticism.’ ”

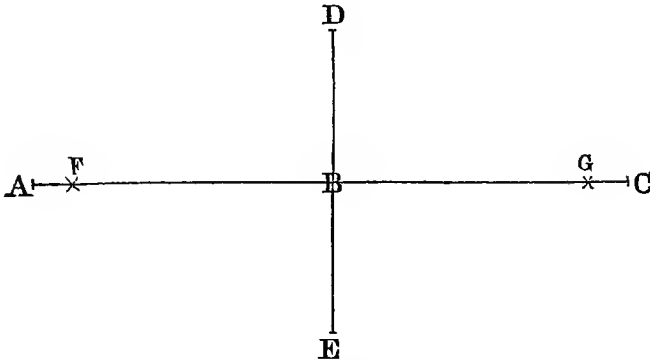
With respect to the nature of the visible curves employed in the Doric order of architecture, Vitruvius says nothing definitely ; and since his time many conflicting opinions have been advanced by those who have written upon the subject.

* *Architectural Maxims and Theorems*, &c. By Thomas Leverton Donaldson, M.R.I.B.A., Professor of Architecture in the University College, London, &c. London : J. Weale.

Penrose says that the entases of the columns are hyperbolic curves; that the soffit of the corona of the pediment is a curve of the same kind; and that the echinus of the capital is composed of two different hyperbolic curves and one circular curve. In order to prove this, he gives offsets, carefully measured from a stretched wire, along with the illustrations of these parts; and this mode of proof would, at first sight, seem conclusive, but it can only be so in the absence of a knowledge of the composite ellipse, and of the various other modes in which ellipses may be combined; for an acquaintance with these will shew that arcs of the composite, mixed, or inclined ellipse resemble so closely those of the hyperbola and parabola, that the one may very easily be mistaken for the other.

In proof of this, I have applied to two of my elliptical illustrations (Plates VI. and VII.) the offsets by which Mr Penrose endeavours to prove the hyperbolic nature of their curves, and they seem to agree as well with the one as with the other. The fact appears to be, that the nature even of a regular ellipse is little known, and seems to form no part of architectural education at the present period. Mr Penrose himself says, "By whatever means an ellipse is to be constructed mechanically, it is a work of time (if not of absolute faculty) so to arrange the foci, &c., as to produce an ellipse of any exact length and breadth which may be desired." This, however, is far from being the case; for any one acquainted with the nature of this beautiful curvilinear figure can in one minute arrange the foci of any one of its almost endless varieties by the following simple process:—Let ABC be the length of the ellipse, and DBE its breadth. Take AB on the compasses, and place the point of one leg upon E, and the point of the other upon the line AB—it will meet at F, which is one focus; keeping the point of the one leg

upon E, remove the point of the other to the line BC, and it will meet it at G, which is the other focus.*



In the absence, therefore, of this knowledge of the nature of the regular ellipse, it is not to be wondered at that those curves which are evidently derived from its harmonic combination should be mistaken for those of a hyperbolic or parabolic kind, which they sometimes so closely resemble. Mr Penrose says, that the Greek architects of the Periclean period, from this assumed difficulty, were forced, in forming the flutes of columns, to adopt an approximate ellipse (made up of arcs of circles), instead of a true one; but this is a mistake, for, having obtained a correct mould or templet from a cast of the upper part of one of the columns of the Parthenon, I found the curve of the flute to be two arcs of an ellipse of ($\frac{1}{4}$), of which NO, OP, QR, and ST, Plate XII., are semi-^{Pla}axes, and u, v, x, y foci. It is surely much more reasonable to suppose that the Greek architects of that period were thoroughly acquainted with the nature of the ellipse, the simplest method of mechanically fixing its foci and describing

* By a very simple machine, which I have lately invented, an ellipse of any given proportions, and of any size from half an inch to fifty feet or upwards, can be easily and correctly described—the given length and angle of the intended ellipse being all that is required to be known.

its circumference, than to suppose that, for want of a knowledge so easily acquired, they were compelled to imitate elliptic curves by combining arcs of circles of various diameters. And it is equally reasonable to believe that they were sufficiently acquainted with the best modes of harmoniously composing arcs of this simple curve, in the production of new and beautiful forms, to prevent the necessity of their adopting the more complex and less manageable mixtures of arcs of parabolas and hyperbolas, even if these curves were known at the period, which is doubtful.

But I beg here to state, that in thus shewing Mr Penrose to be unacquainted with the nature and use of the elliptic curve, and that he was thereby induced to adopt curves which have no connexion with the elementary forms of architecture, I have no other motive than the support of truth, and trust my doing so can have no tendency in the slightest degree to lower the estimation in which that gentleman's very laborious and highly valuable *Investigation of the Principles of Athenian Architecture* must be held by all who take an interest in the subject. In fact, I quoted Mr Penrose's words as those of a highly educated architect, in order to prove the fact, that the nature of the ellipse forms no part of architectural education at the present period. Indeed, it would appear that a knowledge of the nature of this simple and beautiful figure, and of its value in architectural orthography, formed no element either in the education of the Roman architects, or in that of those of the middle ages, for the curve of the ellipse is equally ignored in the comparatively crude works of the former, and in the semi-barbarous productions of the latter.

In conclusion, I beg to offer a few remarks upon that quality which constitutes the orthographic beauty of all architecture,

viz. harmony—a quality, the existence of which is more or less felt by all, and the feeling often eloquently acknowledged by the best writers on the subject. I have already quoted the words of Professor Cockerell and of Mr Kinnard in proof of the existence of harmony in the orthographic beauty of architecture; the first of these gentlemen observing, that true proportion is, like a concord of musical sounds on the ear, conceived and confessed by the eye to be obvious and unalterable; and the second assuring us, that when he first viewed the Parthenon its proportions left an impression on his mind similar to the charm of an harmonious fugue.

In addition to these, I may add the words of Professor T. L. Donaldson, who, in his *Architectural Maxims and Theorems*, observes, “Who shall say that Greek architecture is poor, because its mouldings are few? Seven musical notes have sufficed for thousands of exquisite melodies, and each nation has its own peculiar airs. . . . Beauty consists in the completeness and harmonious relation of all the parts and properties of any object.”

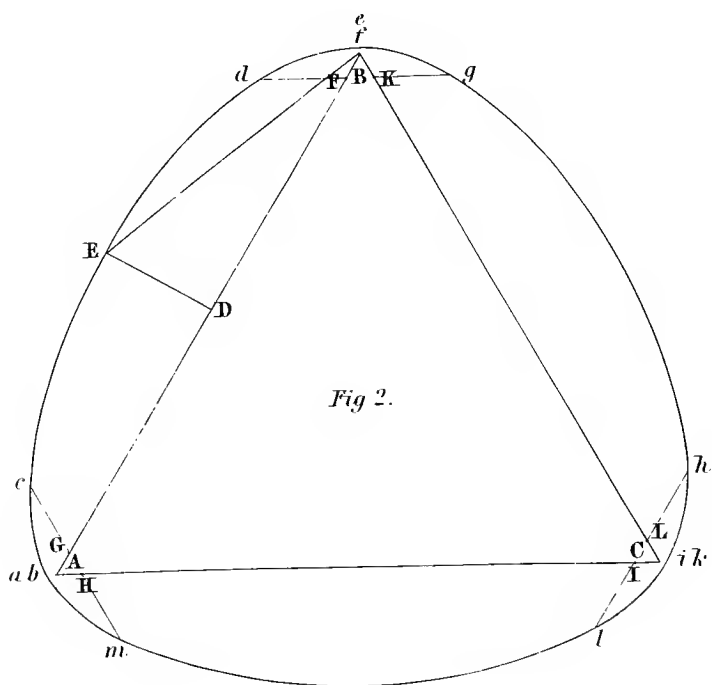
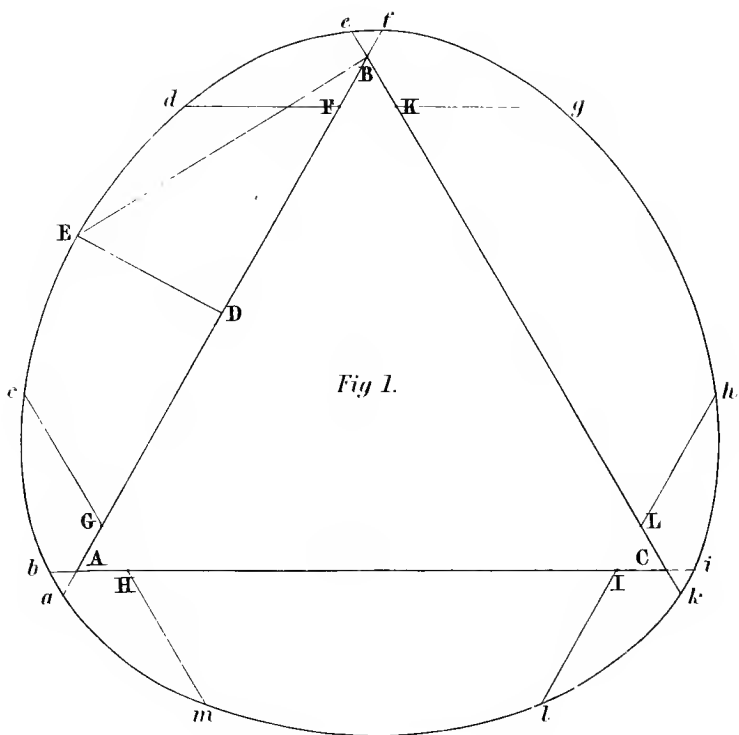
Mr Hosking, the author of the article “Architecture” in the *Encyclopædia Britannica*, truly says, that “simplicity and harmony are the elements of beauty in architecture;” and Mr Penrose terms the Parthenon a “most harmonious structure.”

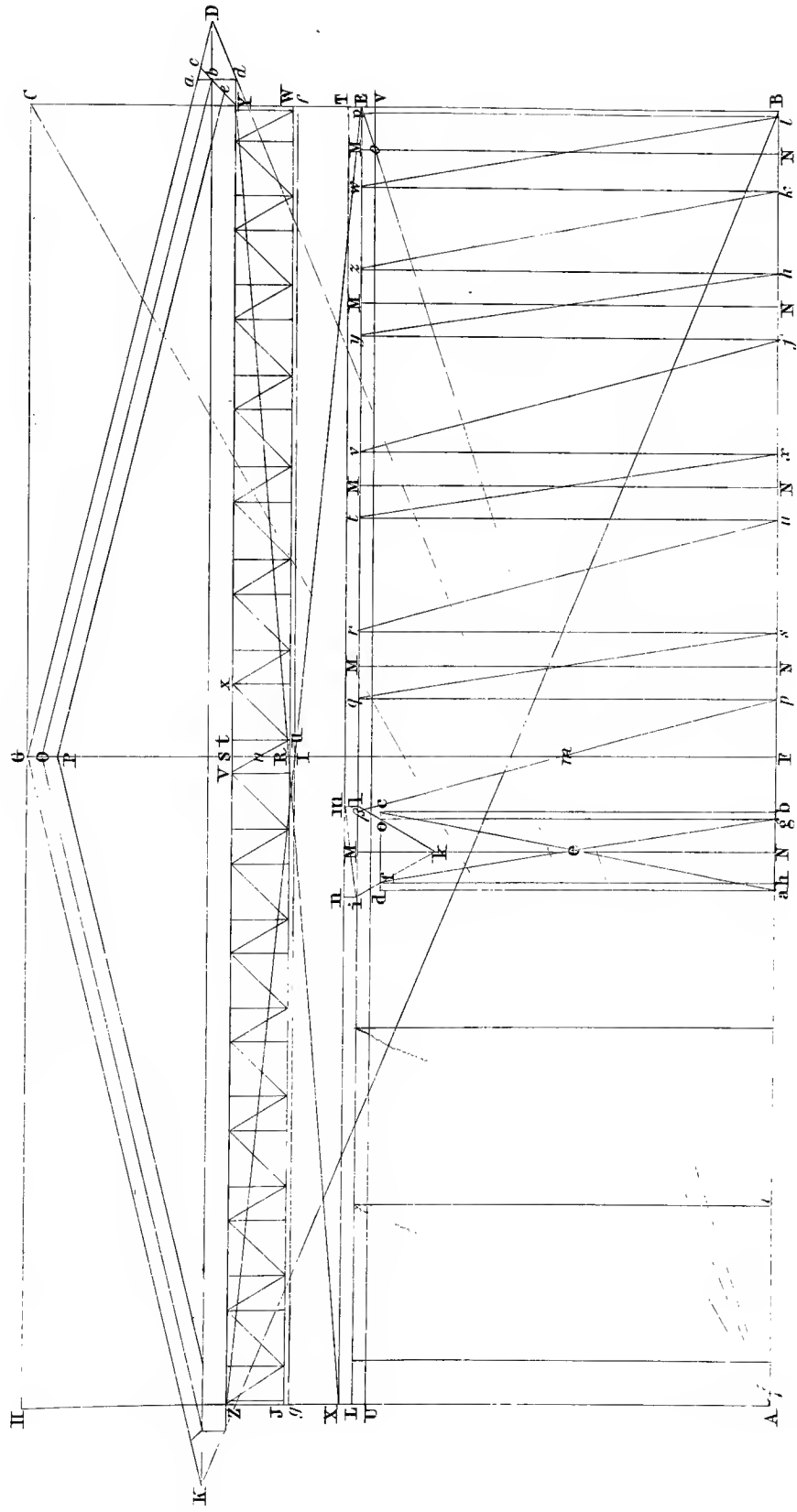
When, however, we inquire into the true nature of harmony, we find that it is not of a vague, indefinite nature, but of a specific character, and founded on a natural law, discovered by Pythagoras, in respect to sound, and since acknowledged as a scientific fact. This discovery proved that the mind is affected by the successive or combined relations of various sounds, according to the numerical ratios of the pulsations or vibratory motions which they individually occasion in the surrounding atmosphere, and that these affections are most

pleasing when their numerical relations are the most simple. Harmony being thus the expression of a law of nature, we cannot impart it to the form of any visible object, unless we find some means of actually applying that law in the construction of such an object. Neither can we feel certain of the existence of harmony in the construction of a work of art, unless we can also trace that quality specifically to the operation of the same law. For the eye does not so readily convey to the mind those harmonic impressions made upon it by external objects, as the ear does in respect to sounds. That harmony exists in respect to the effects produced by colour has been systematically proved by various authors, from Sir Isaac Newton downwards. But with respect to its existence in form, no system has as yet been established such as would enable the architect systematically to impart it to his works.

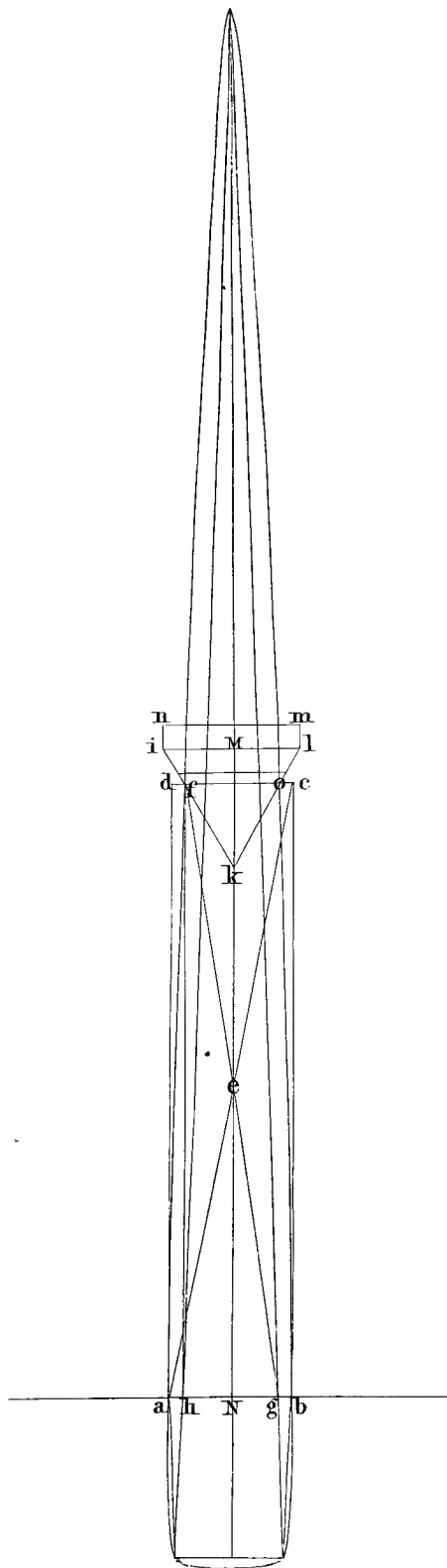
In regard to my present attempt to supply this desideratum, I have only to request, that it may be carefully examined, and to assure my readers, in the words of a great philosopher of antiquity, quoted in a former work, that "if any one can prove that he has found any method yet better and more suitable, he shall be treated, not as an enemy, but as a friend, and his ideas shall prevail."

THE END.

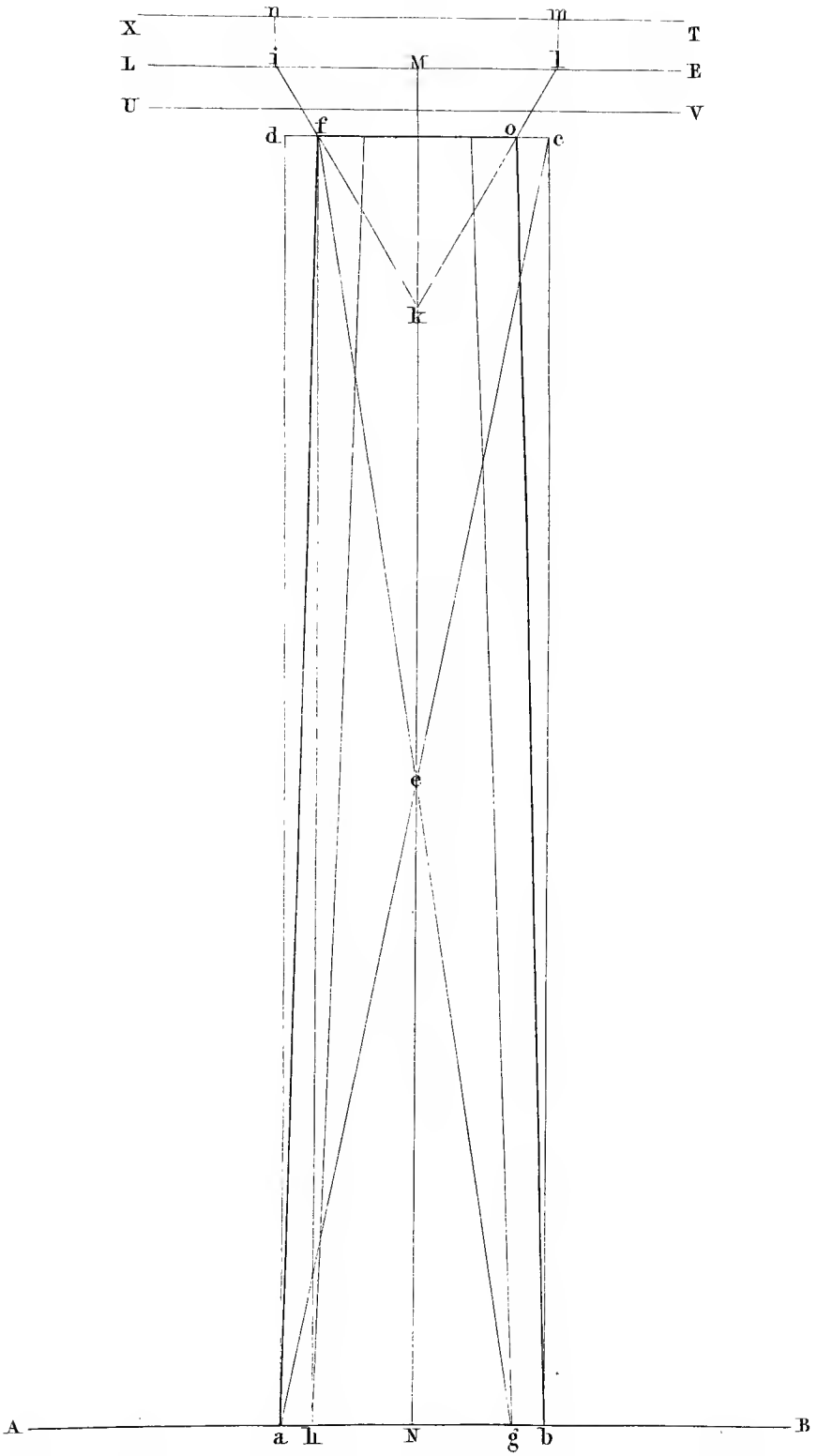


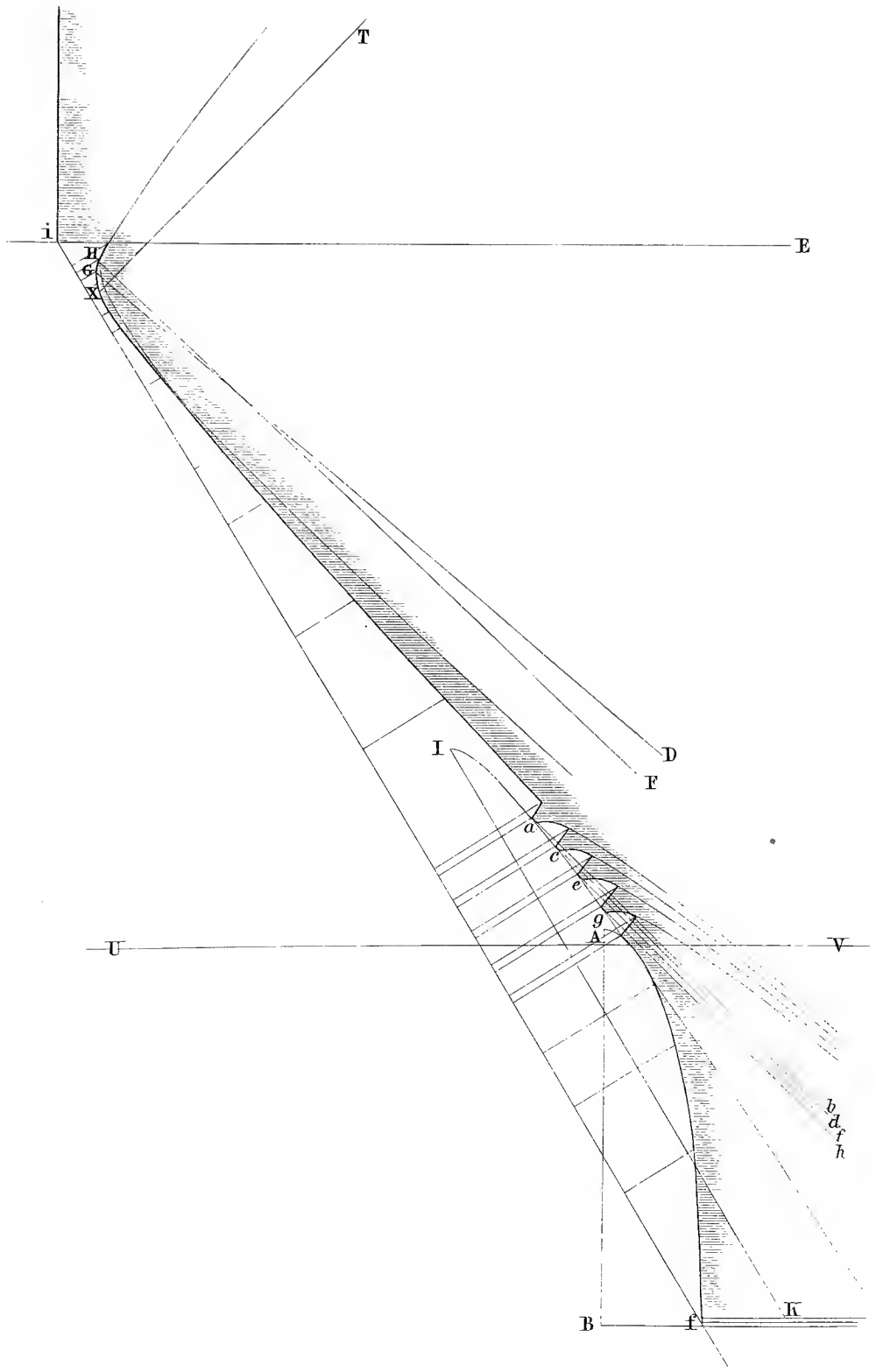


IV.



V.





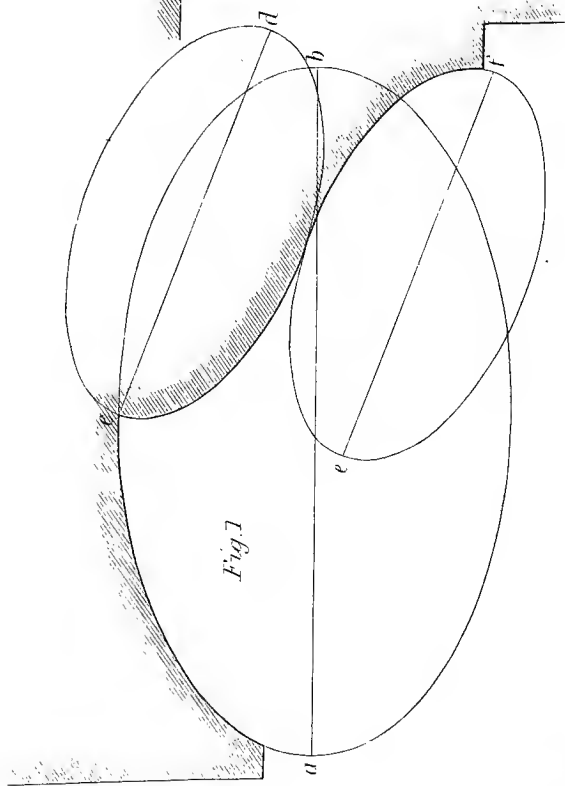


Fig. 1

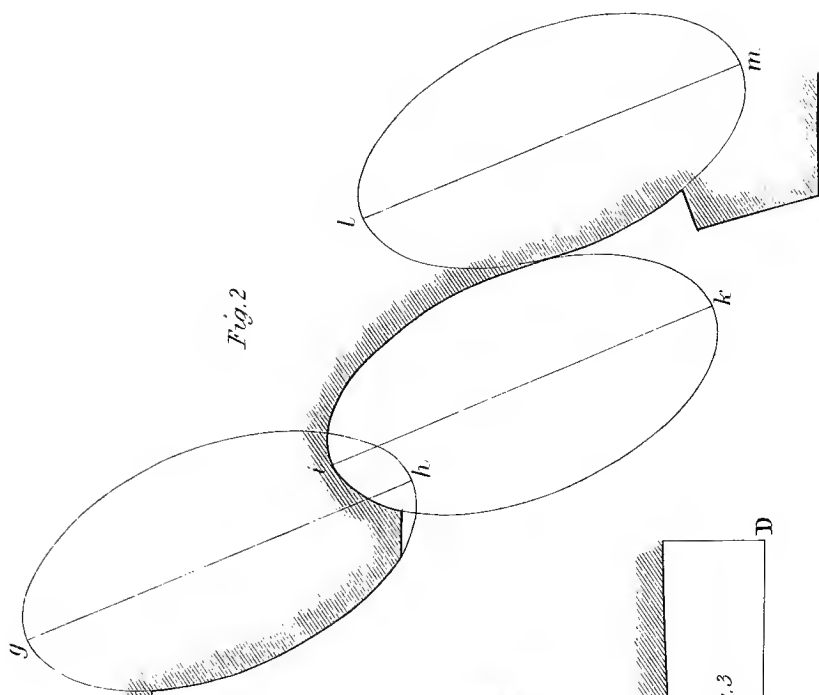


Fig. 2

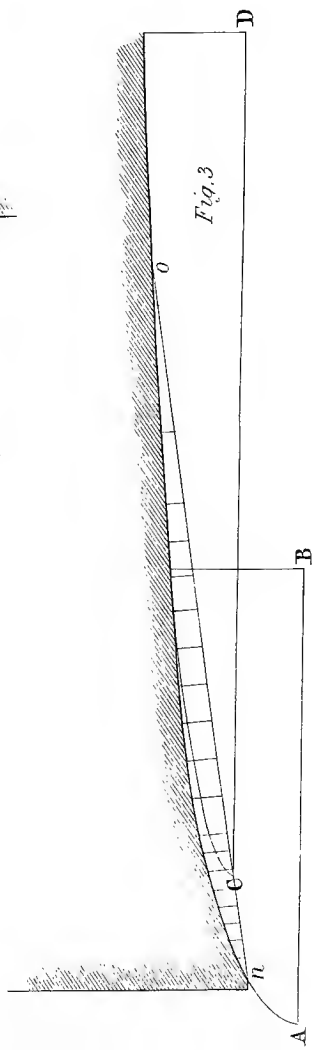


Fig. 3

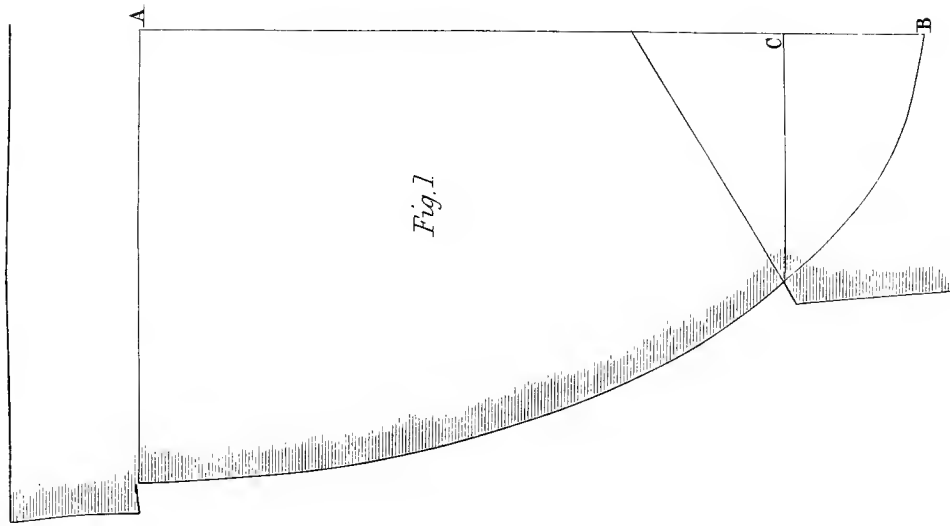


Fig. 1

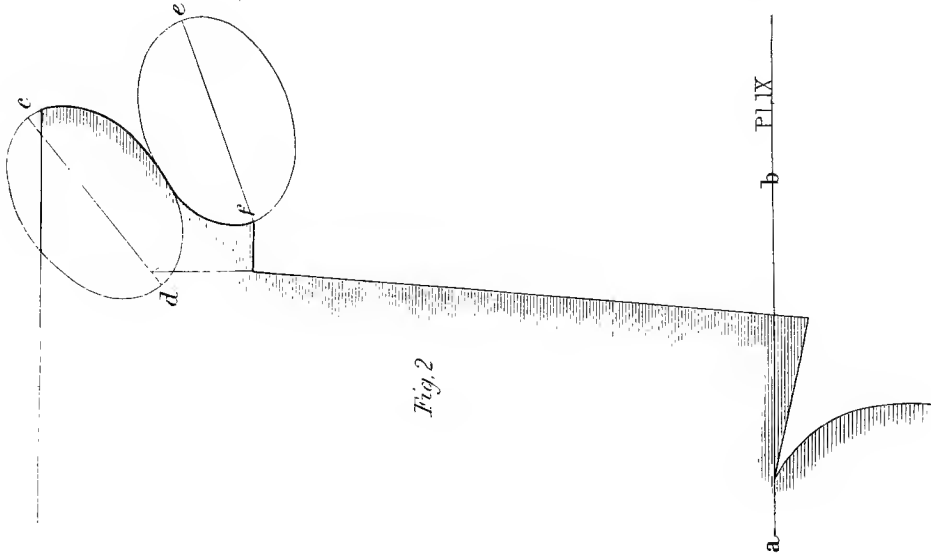


Fig. 2

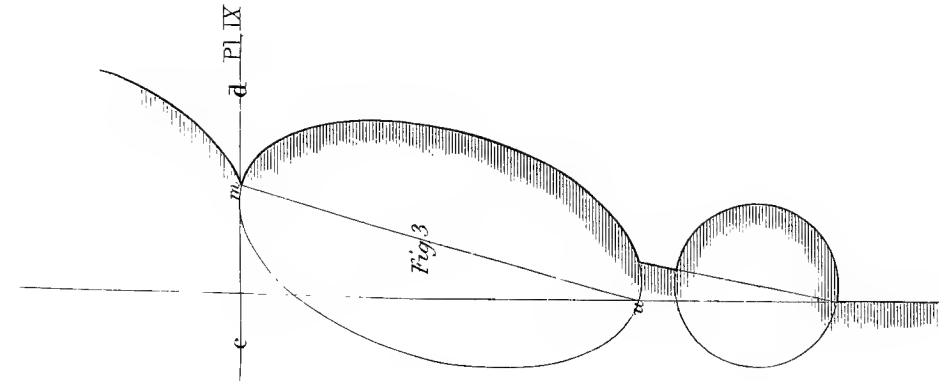
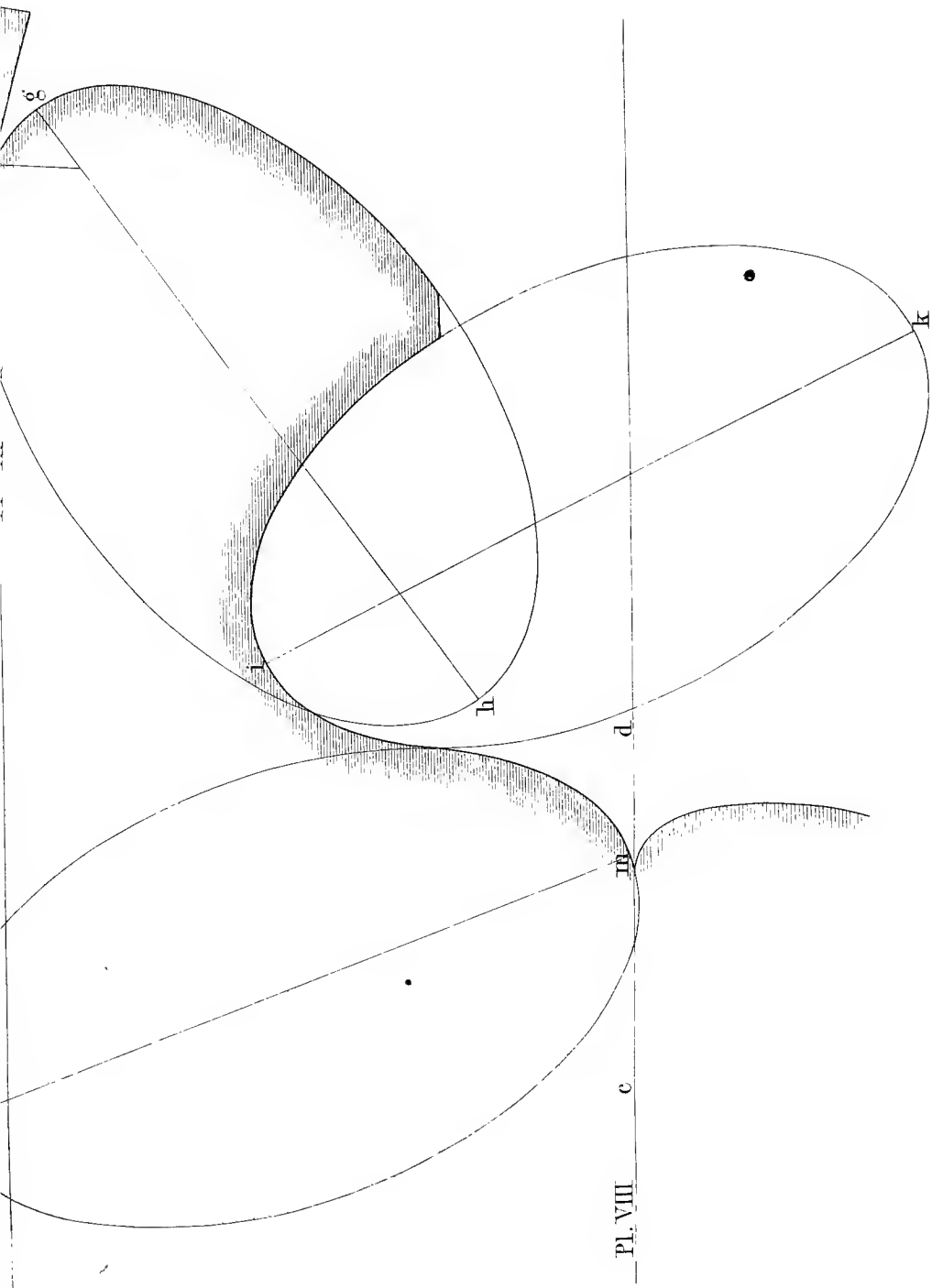


Fig. 3



Pl. VIII

